Positive Mathematical Programming Approach for Ex-post Evaluation of Set Aside in Italy

Filippo Arfini[1] , Michele Donati[1] , Marco Zuppiroli[1] and Quirino Paris[2]

[1] University of Parma, Parma, Italy
[2] University of California, Davis, USA.

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Abstract

The purpose of this paper is to describe the characteristics of a model used for estimate the counterfactual effects of set aside policy in Italy. For this purpose it is used a regional model based on "positive" information contained in two different databases - FADN and IACS-AGEA (an Italian administrative databank), and an evolution of PMP approach able to reproduce and properly simulate the entrepreneurial behaviour in each region. The paper clarifies in detail the procedure used in order to merge two different database and the main issue of the model useful for the proposed ex-post evaluation of relevant policy scenarios applied in agriculture.

Keywords: PMP, Regional Model, Set aside, Policy Evaluation.

1. Introduction

The agricultural policies that had the greatest impact on the organization of production at farm level in the past few years have been characterised by the adoption of measures to sustain farmers' income, in the shape of direct payments in coupled and decoupled form. On one hand, these payments aim to reduce the cost to the farmers themselves of an increasing liberalisation of agricultural world markets or introducing some specific program (as set aside) and, on the other hand, to avoid penalising some categories of farmer too far as a result of the change in payment methods or an excessive reduction in compensatory payments.

However, the agricultural policy tools for sustaining income such as those used until now, have sometimes not seemed very efficient in terms of satisfying the needs and objectives for which they were created. For this reason, *a priori* evaluation of the possible effects caused by

[*] University of Parma, Parma, Italy
[**] University of California, Davis, USA.

these tools, using suitable models, represents a necessary step in the definitive classification of the future effective tools used in agricultural policies. But, also an ex-post evaluation can be considered useful for policy maker because allow to obtain a counterfactual analysis of some specific policies and than evaluate their efficiency.

Concerning the objective of evaluating the effect of these policies by means of models, farm level analysis does not create particular difficulties, but the analysis at regional and national level, which also considers the characteristics of the farms, obliges the researchers to face more complex problems. In fact, in order to meet the objective of developing models able to analyse production and market aspects on a regional and national scale, all information must be available to describe the behaviour of the different typologies of farmers in their territory and suitable methodologies both for data management and economical representation of entrepreneurial behaviour.

The purpose of this paper is to describe how it is possible and useful to estimate the effects and the efficiency of some agricultural policy measures at sub-regional, regional and national level not only ex-ante, but also in ex-post analysis. The model utilised in this study is based on Positive Mathematical Programming (PMP) but represent an evolution from the standard approach (Paris, Howitt, 1998; Paris , Arfini 2000) because allow to consider also the crops-yield variation. For this reason it is used for analyse, in ex-post scenario, the effectiveness of Set aside as tools of agricultural polices able to reduce surplus of COP crops in Italy.

2. The mathematical programming models used for agricultural policy analysis: a brief state of the art

The idea of evaluating the effects of the agricultural policy measures using mathematical programming models is not new, and a path has been clearly documented that leads first of all to the analysis of the farm planning problems, moving later to facing more general agricultural policy problems and only recently including also the analysis of Common Agricultural Policy (CAP) problems.

Consequently, many of these models have the same structure, which remains a microeconomic view of agricultural policy problems. In other words, at the centre of the model there is the farm, the farmer-entrepreneur or the family farm, and their ability to adapt to different agricultural policies or to different market conditions.

Moving on from these observations, the models can be classified according to two main elements. The first is the number of farms, or aggregates of farms, that constitute the sample and the second is the methodology used to solve the policy problem. In relation to the "dimension" of the model, it is possible to distinguish between farm models, regional models and sector models. In relation to the methodology that can be used, it is possible distinguish between Linear Programming (LP), LP associated with econometric estimation, Positive Mathematical Programming (PMP) and Symmetric Positive Equilibrium Problem (SPEP).

To better understand the characteristics of the proposed model, we need briefly to recall the methodological approach that has characterised the development of the regional and sector models.

2.1 Linear Programming and regional model

The first step that led to the creation of regional and sector models was the development of farm models. Farm models, initially, were developed for technical assistance purposes, or to study the impact of price market variation or new agriculture policy measures, and have the undoubted advantage of being simple to construct and useful for showing the observed reality. They also provide the information necessary to construct the technical matrix for the farm under examination, and thus greatly reduce the possibility of error in assessing the farmer's behaviour. But these models do not represent an area or sector because it is not possible to apply statistical inference of the results to the whole universe of farms. In conclusion, the models that show case studies are extremely useful for technical assistance and for estimating the impact on individual farms, but they are much less useful for public decision makers who require information on the effects across an area or production sector.

While farm models present clear limits concerning the possibility to correctly represent a region or sector, the specifically regional or sector models aim to correctly represent the productive structure of a given region or agricultural sector in order to be able to analyse the effects of the market or of agricultural policies.

Using models very similar to farm models, the first attempt to make the models more widely applicable was made during the 1970s. At that time the mainstream was, for a certain region, to consider the n farms in the sample and reduce them to a single representative farm using weighted averages for the parameters needed to construct the model. The biggest problem is the criteria for aggregating farms into the sample compared to the area universe to be represented. It is especially difficult to assess how the sample performs with regard to farm statistics on structure, economics and output.

The following works describe such attempts: Heady and others on American agriculture(1972, 1978), Hazell and Norton (1986) describing the techniques of constructing a model representing the area studied, Hazell and Scandizzo (in Hazell and Norton, 1986) on the agriculture of North-East Brazil and Paris and Ester (1995) on Australian agriculture, Jayet (1990) on French and European agriculture and Reading University model (Jones and others, 1995) on British agricultural system.

Clearly, the most delicate aspect and the biggest limitation of this group of models is obtaining parameters to describe the technology used by types of farms, corresponding to size or the main type of output, even if they are in the same geographical region. It also needs to be noted that if farms are aggregated solely on the basis of structural characteristics, their output orientation and the different degrees of specialisation the entrepreneur chooses tend to be overlooked.

So there tends to be a risk of developing models that do not correctly represent the technology used and thus the costs of the different production processes. This means that the estimate of the entrepreneurs' behaviour represented by the model does not correspond fully to reality and may consequently provide policy makers with flawed indications.

Among the various different models developed in Europe over the past few years, particular interest has been noted in those dealing with the French and British experiences, respectively using the AROPAj[1] and LUAM[2] models, which represent significant examples of regional models based on the use of only Linear Programming and aiming to analyse agricultural policy scenarios.

2.2 Positive Mathematical Programming and regional models

To consider the problems described above (to make the linear programming model more able to represent the production choices made by homogeneous groups of farms), some of the theoretical and methodological aspects of mathematical programming and, in particular, linear programming, were developed to provide greater capacity to analyse the problems of agricultural policy.

In this way that normative LP model aimed at identifying the "best" production combination under the hypothesis that the initial situation is not binding in terms of production choices, has been left behind for the positive type model, where the main objective is to precisely reproduce the observed production situation in order to be able to simulate the best behaviour of the farmers in varying the parameters involved in the agricultural policy intervention.

This path began with the work of Heady (1964, 1978) and Howitt (1995) and continued thanks to the work of Paris and Arfini (1995) and Paris and Howitt (1998) who, precisely as a result of the stimuli from the development of EU agricultural policy problems, created a new methodological approach called "Positive Mathematical Programming" (PMP). In particular, thanks to PMP it has been possible to reduce the research phase concerning the estimation of technical coefficients allowing for the possibility to directly use the data contained in the agricultural accountancy databanks (such as the European or the UK-FBS) without any kind of manipulation or estimation that could, among other things, imply in some cases the subjective evaluation by the researchers. Since 1995 many works using PMP have been available, analysing the effects of the Common Agricultural Policy (CAP) reform at sub-regional, regional, national and European level. The success of this methodology is confirmed by the fact that

[1] The AROPAJ model (Jayet, 1990) was developed by the INRA Agricultural Research Centre at Grignon in order to use linear programming to analyse the effect of the CAP in France and, with an adequate database, the rest of Europe. It can be considered a regional model, because every model focused on the NUTS 2 area and became national by adding together different regions

[2] LUAM was developed by the University of Reading, and is an acronym of Land Use Allocation Model. It was created in 1985 at the Farm Management Unit at Reading University and was gradually implemented with the help of the Ministry of Agriculture in order to assess the effects of the CAP at regional levels.

two European Union-financed research projects (CAPRI and EUROTOOLS3) use PMP to develop CAP analysis models.

These models, which use the same basic PMP methodology and the same FADN data-bank, show in reality some differences, stemming from the different ways of "interpreting" the PMP as developed in the initial works by Howitt and Paris. Among the works developed using PMP we should mention the models of INRA-Nancy (Barkaoui, Butault and Ruosselle, 1999)4, University of Madrid (Judez 2000)5, University of Galway (Garvey and Steele, 1998)6, University of Bonn (Hackeley and Britz, 2001)7, the FAL model (Kleinhanss, 2002)8 and the integration among different approaches (Paris and others, 2001).

The following step in the path of develop models able to describe the behaviour of the farmers aggregated in specific regional or sector model was introduced by Paris and Howitt (2001) and Paris (2001) where the explicit maximization of net revenue is no longer postulated. In place of the LP maximization/minimization objective characteristic of the traditional phase 1, was introduced the notion of equilibrium problem. At the same time, the calibrating phase 3 no longer includes the fixed-coefficient technology appearing in phase 1. Even this phase was expressed as an equilibrium problem between demand and supply functions of inputs and marginal cost and marginal revenue of the output activities.

Many of these models have the common characteristic of using regional data bank (i.e. FADN) as the sole source of data, and of constructing models by region and farm type. The farm type is made from an average farm, "representative" of a group of farms with the same production orientation and reproduced using PMP models; or rather, a model for each considered type. It is only in the work of Paris and Arfini (1999 and 2000), thanks to the "self-selection" approach, that the behaviour of every single farm present in the same Farm Type (FT) class is reproduced in all its specificities, adding greater value to the information concerning the characteristics of the farms included in the FADN sample.

The biggest problem common to all the models described is however their representativity with respect to the regional universe, and the fact that this is strictly linked to the representativity of the FADN sample. The latter should be guaranteed at regional level for each FT, but is obviously reduced when passing from level NUTS2 to NUTS3, and further reduced if a further subdivision of the farms is made, such as for example, size class. The biggest risk is there-

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[3] CAPRI and EUROTOOLS are acronyms relating to two research projects. The first (Common Agriculture Policy Regionalized Impact Analysis) coordinated by the University of Bonn, and the second (Tools For Evaluating EU Agricultural Policies At Different Decision Level), coordinated by the University of Bologna.

[4] This model is based on FADN data for 12 EU countries subdivided by region (NUTS2) and by FT class. Also in this case we find an "average" representative farm whose production specialisation is described using the FT class. Allows for the simulation of the land use policies and considers a technical progress function

[5] The model is based on the construction of a "representative" farm respect the Farm Type of a given region. Data are taken from the mean of those farms with the same FT present in the FADN sample of the region

[6] The model applies fully the PMP to single representative farms chosen according to technical orientation (FT) and physical size.

[7] The model aim to develop a regional supply model for each EU member state based on expected prices where, in contrast to Howitt and Paris' initial structure, they use an historic series of observations providing a stronger statistical base for the estimation of the parameters that constitute the technical matrix and the cost function

[8] The model is useful for regional estimation, is based on the use of the FADN database to and define the representative farms in each single FT at regional level

fore that of using models that do not provide a correct picture of the real situation, by reproducing instead a blurred image of the effects of the agricultural policy measures for a whole region.

2.3 The organisation of the regional model for set aside counterfactual analysis

According to the above picture, we need to develop a model able to simulate possible agricultural policy scenarios at regional level, guaranteeing on one hand, good statistical representativity, and on the other hand methodological correctness in describing the behaviour of the farmers. For these reasons the objective of the model proposed in this work is to overcome some limits which stem from the separate use of different sources of data, increasing the potential of the Mathematical Programming (MP) to estimate and reproduce the cost function for each farm type in every single region, obtaining an agricultural policy tool that is at the same time flexible and complete.

Concretely, the creation of the proposed regional and national model of agricultural policy requires a specific database able to unite and integrate different statistical sources, and a methodology able to estimate the cost functions of the farms, calibrate the models with respect to the observed reality and carry out agricultural policy analysis at regional level.

More specifically, the statistical sources used are the IACS and FADN databanks, integrated between them by a specific procedure of aggregation which foresee: a) the extraction of the data from two databases; b) the control of the data quality; c) the organisation of a new integrated database; d) the organisation of the input data in an adequate form for the PMP software model.

On the other hand, the methodology used to estimate the cost function, the calibration and the simulation of the agricultural policy scenario (in this case set aside) is represented by a modification of SPEP presented by Paris and Howitt (1991) and Paris (1991).

In contrast to the models described above, the regional model presented in this paper, does not need an extension to the universe, allowing a direct evaluation at regional level of the effects of the different agricultural policy measures. This result is achieved by the integration of IACS databank with FADN and subdividing NUTS 2 region into correspondence NUTS 3 sub-regions. At this stage SPEP methodology is able to estimate the cost function of each one sub-region, and to calibrate them with respect to the observed reality.

Schematically, each region is defined by splitting the territory into: a) administrative provinces (NUTS 3), b) altimetry and c) macro-farms. The latter are defined by aggregating all the farms registered under Regulation 1251/99 (and registered in the IACS database) according their AAU size. In this model we considered 10 farm AAU size classes (0-5 ha; 5-10- ha; 10-20 ha, 20-30 ha; 30-40 ha; 40-50 ha; 50-70 ha; 70-100 ha; 100-300 Ha; > 300 ha), each of which constitutes a "macro-farm" containing all the activities and economic data relating to the processes observed. This level of aggregation represent the "sub-region" reproduced by the model and can be considered an important territorial unit because is homogenous respect the level of direct payment.

Within each macro-farm identified in each homogeneous area, all processes present will be considered once they have been organised into the following groups of processes: a) COP crops: cereal, corn, split and waxed corn, protein cereals and flax; b) Other open field crops: horticultural, industrial crops, tobacco; c) Fodder: alfalfa, fodder plants, grass meadows.

Essentially, the model refers to 10 types of farms (T=10), each representing one "virtual" macro-farm with a maximum of 15 activities (J=15), where: a) FADN supplies yields, output price and input cost; IACS provide surfaces and number of heads. This model is also integrated with other data concerning the level of subsidies, such as the compensatory payments for each individual process the farm has the right to, or any possible measures for production reduction, such as set aside.

The following phase of agricultural policy evaluation is done by gathering together every calibrated sub-regional model into a single regional or national model, where the objective function is the sum of the objective functions of every single sub-region, linked to the connected sub-regional technical matrices. The maximisation process of the aggregated objective function provides us with an "optimal" solution for the entire model, which is also "local optimal" for each sub-region. Organised in this way, in the policy scenario analysis phase the model will lead to an overall representation of the behaviour of the farmers represented in the individual types of macro-farms present in the observed region.

3. The FADN, IACS and the new Integrated Database

As argued in the previous paragraphs, behind the regional simulation models there must be a set of data able to guarantee a suitable level of coverage of the information with respect to the needs of the model, and of representativity with respect to the observed reality. However the data needed cannot always be found in one single database, and when this happens, as in the case of FADN, a suitable level of representativity cannot always be guaranteed. From here, we need to use different statistical sources, using the information that is best suited to both the construction of the model and the policy objectives.

In particular, in this model two different databanks that operate at regional level, FADN and IACS, have been used. Obviously each databank introduces characteristics that influence or limit their use. For this reason the main characteristics of both are illustrated in the following paragraphs.

3.1 The FADN databank

FADN represents the most important source of information on the structural, economical and productive characteristics of European agriculture. This databank has the great merit of recording, for each farm, information that links it to the Farm Type, to the Economical size (Class of ESU), the physical size (Class of AAU) and to the region in which the firm is located[9]. For every farm all the information relating to the use of the land, productivity, production cost and income is also recorded. From a theoretical point of view, FADN is "the ideal" instrument for all researchers, because it contains all the necessary information for the construction of an agricultural policy analysis model. Unfortunately, from a practical point of view, FADN in fact presents great limits that influence its use[10].

In detail, the FADN information considered for each farm process and farm type (represented by the macro-farm) present in each sub-region, are those that best reflect the behaviour of the farmer, including: a) the value of the yield for each process; b) the unit output prices for the goods sold on the market; c)the unit cost (where is possible) of the inputs used for each process.

3.2 The IACS databank

The Integrated Administration and Control System (named IACS databank) is considered an administrative databank, because its function is to record the characteristics of the farmers who join in the Common Market Organisations under the CAP. These data banks are created with a twofold objective: to facilitate the bureaucratic aspects for the farmers and to facilitate the control of the data and the payment of subsidies for the public bodies (mainly the Regions Administration).

With reference of Italy, the Italian Minister of Agriculture (MIPA) has created a specific administrative data bank (called IACS-AGEA[11]) that collects all the data related to the farmers who are registered in the Reg. 1251/99. The information's contained in IACS-AGEA databank has the characteristic of being:

- Reliable, because the farmers are obliged to tell the truth;
- Detailed, because they are contain precise details of the farms' land use practices;
- Statistically correct, because based on surveys of all the farmers universe;
- Timely, because they are updated annually.

For these peculiar characteristics, the IACS-AGEA databank can be useful for overcoming the main gap of the FADN: the low level of representativity of the farm typologies at sub-regional level and especially of the land use between different crops. The IACS-AGEA databank therefore has the important task to provide the data related to the land use of each activity. In other words, thanks to this reliable databank it is possible to obtain a reliable image, at sub-regional and (by combining the data) national level of the use of the land between different crops.

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[9] Further information may be found in the websites http://europa.eu.int/comm/agriculture/rica/index and http://www.inea.it/rica/index.html

[10] The most important limits can be considered as: it is not a constant sample; a) the sample cannot be considered representative at sub-regional level; b) the variable costs related to single input are not recorded; c) the amounts of inputs related to single process are not recorded.

[11] The IACS-AGEA databank owes its name to the Italian Agency created by the Italian Ministry of Agriculture, AGEA, which makes payments to farmers and carries out the necessary controls.

It should be underlined that the data contained in the database comes from the paper forms filled in by the farmers when presenting their applications, and provides a detailed description of the size (in Ha) of the crop processes actually practiced at the farm, and assigns a code to them. The main characteristic of the IACS-AGEA databank is at the same time also its main limit, because it does not provide any indication of crop yields, prices and costs.

Merging the FADN and IACS-AGEA databanks, it is possible provide more complete information on the characteristics of the macro-farms, supplying precise information on the participation in European programmes with the estimation of the overall compensatory payments received. Furthermore these farms can be considered to be those with the greatest awareness of the agricultural policy measures involved in the individual sub-regions, simply because they have taken part in the Community programmes.

Within the same sub-region, the integration of information between the two databanks is carried out at macro-farm level, thanks to the presence of the common variable represented by the crop process identification code used in FADN and IACS-AGEA.

4. The mathematical structure of the model

The theoretical framework adopted for analyse the impact of set aside in Italy is based upon an integration between some theoretical aspect of SPEP, described in the works of Paris and Howitt (2001) and Paris (2001), and PMP, obtaining an interesting extension of previous PMP approach. As a mathematical process to analyse the behaviour of the farmers, therefore, considering at the same time the presence of N-farms in a data sample, giving them the opportunity to not carry out processes that are not economically convenient thanks to the self-selection technique.

The extension from the traditional PMP model was necessary for two basic reasons:

- In EU-FADN, the variable costs for each production activity observed are not considered. These data represents an important element of the traditional PMP approach, as indicated by Paris ad Howitt (1998), and are the "countable costs" that provides more information for estimating the matrix of total variable costs, described in the paper, as the Q matrix. For this reason the equilibrium problem used by SPEP give us the to estimate the total cost of the farm, overcoming the problem related to the observed variable cost as part of the information useful for estimate the Q matrix.
- Because set aside imply, as a consequence, the possibility to face a "slippage" effect (or better, the possibility of changing the level of intensification of the activity changing the COP-crop yield on the surface area that is not used for set aside), it also necessary no longer includes fixed-coefficient technology appearing in phase 1 of PMP. Also this phase is expressed as an equilibrium problem between demand and supply functions of inputs and marginal cost and marginal revenue of the output activities.

In order to introduce these two import issues in the present model, the well- known three phases of the PMP framework were developed as follows:

Phase 1. The objective of this phase is the estimation of the marginal costs of the crop outputs and the shadow price of land. Each region in Italy was characterised by several representative farms. Not all farms produced all the crops identified in the given region. This self-selection aspect of the problem had to be taken into account explicitly. The Phase 1 model, as in the PMP methodology, can be stated as follows:

$$\max_{\mathbf{x}_n, \mathbf{h}_n} \{\mathbf{p}_n'\mathbf{x}_n + \mathbf{s}_n'\mathbf{h}_n\}$$

$$\text{subject to} \quad \mathbf{a}_n'\mathbf{x}_n \le b_n$$
$$\mathbf{x}_n \le \mathbf{x}_{Rn}(1+\varepsilon)$$
$$\mathbf{D}_{\mathbf{a}n}\mathbf{x}_n - \mathbf{h}_n = \mathbf{0} \qquad n = 1, \ldots, \text{N}. \tag{1}$$

where $\mathbf{p}_n, \mathbf{x}_n, \mathbf{s}_n, \mathbf{h}_n$ are output prices, output quantities, per hectare subsidies, and crop hectares, respectively. As there is only a land constraint in this model, the b_n parameter is the supply (availability) of agricultural land in the n-th representative farm and $\mathbf{a}_n$ is the corresponding vector of technical coefficients. This vector also includes a set aside activity that captures the voluntary level of set aside within the n-th farm. The $\mathbf{D}_{\mathbf{a}n}$ parameter is a diagonal matrix with the elements of the $\mathbf{a}_n$ vector on the diagonal. The $\mathbf{x}_{Rn}$ parameter is the vector of realised output levels and ε is an arbitrarily small parameter. The vector $\mathbf{x}_{Rn}$ also includes the zero value of crop levels not considered by the n-th farm.

The main result of this phase is the expression of the latent dual variables associated with the various constraints as necessary inputs for defining the marginal cost of the various crop activities and the demand for inputs.

Phase 2. The information extracted from Phase 1 is used in this second phase to reconstruct the regional cost function using data from all the N farms of the sample. An interesting feature of this overall cost function is that it encompasses all the crops that were cultivated in the region, and yet it calibrates the production scenario of every single farm even though each farm did not cultivate some of the crops.

The framework for reconstructing the cost function is the simultaneous estimation of the parameters of the marginal cost relations and the associated Shephard lemma as follows:

$$\frac{\partial C}{\partial \mathbf{x}_n} = \mathbf{f}(\mathbf{y}_{LPn}'\mathbf{u}) + \mathbf{Q}\mathbf{x}_{LPn}(\mathbf{y}_{LPn}'\mathbf{u}) + \mathbf{d}_{\mathbf{x}n} = \mathbf{A}_n'\mathbf{y}_{LPn} + \boldsymbol{\lambda}_{LPn} \tag{2}$$

where $\mathbf{f}$ and $\mathbf{Q}$ are parameters common to all farms and, thus, defining the regional cost function while $\mathbf{d}_{\mathbf{x}n}$ is a vector of deviations from the regional cost function that identify the n-th farm's marginal cost function. The $\mathbf{u}$ vector contains all unit elements. The Shephard lemma is implemented as

$$\frac{\partial C}{\partial \mathbf{y}_n} = (\mathbf{f}'\mathbf{x}_{LPn})\mathbf{u} + (\mathbf{x}'_{LPn}\mathbf{Q}\mathbf{x}_{LPn}/2)\mathbf{u} + \boldsymbol{\Delta}_{\mathbf{y}^{-.5}}\mathbf{S}\mathbf{y}^{.5}_{LPn} + \mathbf{d}_{\mathbf{y}n} = \mathbf{A}_n\mathbf{x}_{LPn} \tag{3}$$

where $\mathbf{d}_{\mathbf{y}n}$ is a vector of deviations from the regional cost function that identify the n-th farm's demands for limiting inputs.

The marginal relations represented by equations (2) and (3) correspond to an overall cost function expressed by the following functional form

$$C(\mathbf{x},\mathbf{y}) = (\mathbf{f}'\mathbf{x}_n)(\mathbf{u}'\mathbf{y}_n) + (\mathbf{x}'_n\mathbf{Q}\mathbf{x}_n/2)(\mathbf{u}'\mathbf{y}_n) + \mathbf{y}'^{.5}_n\mathbf{S}\mathbf{y}^{.5}_n + \mathbf{d}'_{\mathbf{y}n}\mathbf{y}_n + \mathbf{d}'_{\mathbf{x}n}\mathbf{x}_n\,. \tag{5}$$

Economic theory requires that the $\mathbf{Q}$ matrix be symmetric and positive semidefinite. Furthermore, all the elements of the S matrix are required to be nonnegative. The elements of all the other three vectors of parameters ($\mathbf{f}, \mathbf{d}_{\mathbf{x}n}, \mathbf{d}_{\mathbf{y}n}$) are unrestricted. The specification of the cost function in relations (2), (3) and (4) includes several limiting inputs although in the empirical model only land is considered.

The estimation of the cost function parameters is executed using a GME approach and using the information of all the N farms.

Phase 3. The third phase of PMP model is usually called the calibration phase. It is also associated with the analysis of policy scenarios. For the set aside analysis, the main scenario is the reduction to a zero level of the set aside subsidy (by setting the corresponding coefficient of the $\mathbf{s}_n$ vector equal to zero) accorded for voluntary set aside of agricultural land and the reconstitution of the total farm land availability by the addition of the obligatory amount of set aside land by which the land supply was reduced in Phase 1. The model in this policy scenario takes on the following structure:

$$\max_{\mathbf{x}_n,\mathbf{h}_n} \{\mathbf{p}'_n\mathbf{x}_n + \mathbf{s}'_n\mathbf{h}_n - \mathbf{d}'_{\mathbf{x}n}\mathbf{x}_n\}$$

$$\text{subject to} \quad \begin{aligned} \mathbf{f}'\mathbf{x}_n + \mathbf{x}'_n\mathbf{Q}\mathbf{x}_n/2 + S + d_{yn} &\le b_n \\ \mathbf{D}_{\mathbf{a}n}\mathbf{x}_n - \mathbf{h}_n &= \mathbf{0} \\ \mathbf{u}'\mathbf{h}_n &= b_n \end{aligned} \tag{5}$$

In this model, the demand for land expressed by relation (3) allows for variable yields as the market conditions change. In order to implement this feature the coefficient $\mathbf{D}_{\mathbf{a}n}$ is determined by the solution of model (5). For this reason, the parameter is constrained within an interval of ten percent with respect to the sample value in model (1). The third constraint guarantees that all the available land is allocated to the available crops. Given the structure of model (5), the shadow price of land is given by the sum of the dual variables of the first and third constraints.

To resume, the main characteristics of the proposed methodology are:

- The estimation of the total cost function for each "aggregate-farm", from very basic information such as the total volume of output per crop, the amount of farm land and market price per crop;
- To allow the variation of the crop yields and observing the slippage effect for COP-Crops;
- To allow the introduction of a set aside policy, where set aside is considered as a "non-mandatory" activity. This characteristic of the model allow the calibration of the set aside at the baseline level on the base of its economic convenience.

4.2 Regional aggregation of the Set aside PMP models

The model used in this study is therefore a regional model in which information on the farms are aggregated at sub-regional level (NUTS3) and, by an evolution of PMP approach, held in a simulation phase in order to provide responses to agricultural policy change that are as representative as possible of the characteristics of each sub-region and the farms within it.

From a methodological point of view, the particularity of this model lies in the means of aggregation of the single sub-regional models allowing the introduction of constraints at regional level.

In many regional models, for which literature is available, as previously examined, the simulation process involved the resolution of a problem of optimisation for each single sub-region, without therefore considering the complex constraints set at regional level and the profitability expressed by the other sub-regions within the same region. In the present regional model, on the other hand, the simulation phase includes the maximisation of an objective function aggregated by group of sub-regions that comprise the region under examination.

For this reason, the model appears as a model in which, during the policy scenario, the decisions taken by each sub-region are linked to the decisions taken by the bordering sub-regions through the definition of a problem of simultaneous optimisation. In the phase concerning the reproduction of the effects of the agricultural policy measures at regional level, the relevant aspects of the model are therefore the aggregation of the cost functions into a single regional model, and the construction of a suitable set of constraints able to correctly simulate the policies for the whole region.

5. Counterfactual evaluation of set aside measure

All the models described in the previously was applied in context of ex-ante evaluations with the objective to provide to policy makers a scenario of consequences of different political decisions without any political costs.

Ex-post evaluation aims at establishing a well founded judgement whether a CMO and policy instruments included achieve their objectives at reasonable cost. In this context, modelling provided tools to examine what would have happened if instruments would have been different from what the actually were. In the evaluation quantitative tools/modelling will be combined with other, qualitative sources of information.

In the ex-post simulations, policies or individual policy instruments are assessed or/and compared with what would happened without those policy instruments. Policies to be evaluated can be compared with alternative counterfactual situations constructed with the help of a model. Models can help understand how the CMO is supposed to generate its effect and whether it actually did so. Models can also make clear how the effects of the instruments are influenced by other policy interventions and by external factors.

Regarding the use of models in assessing ex-post the effectiveness and the efficiency of the policy instruments, there is, however, relatively little experience so far (Burrel, 1995; Bascou, 2000; Ahner, 2001).

In the case of set aside, ex-post evaluation analysis is carry on calibrating the models in presence of set aside policy (defined in the McSharry reform as mandatory set aside for all the big producers), as appear from the 1999 observed situation, and simulate the policy scenario of voluntary set aside also for big producers.

5.1 A brief history of set aside policy in Italy

Set aside policy in Europe began in 1988 with Regulations EEC 1094/88 and 1272/88 (this last one receipted in Italy with the Law n.106 of the 27/04/1988 in force from the 30/04/1988). This Regulation was created as an instrument "imposed by the necessity to reduce gradually the production of the exceeding sectors". Also, "the improvement of the efficiency of the structures is an indispensable element of the development of CAP", so far Set aside becomes an instrument at the service not only of the control of the production and therefore, of the competitiveness of the European products on the market, but also at the service of the qualitative improvement of structural type. However, it remains an additional measure to support to the farmers incomes that from the half of 80's, decreased in consisting way the prices of their products.

The turning point of the CAP happened in 1992 with Reg.Cee 1765/92, better famous like Reform Mac Sharry. The Set Aside becomes part, from this moment, of an integrated program of long run and it was not, as happened for the previous legislation, an instrument of agricultural policies apparently nearly unbounded from all the other provisions. In the Reform Mac Sharry Set Aside objectives melt with all the other measures of European agricultural policies in the attempt to form an organic block of dispositions in order to achieve CAP objectives.

Set Aside becomes obligatory for the farms belonging to the general regime, while was optional for the simplified one; within the obligatory scheme a rate of 15% Set Aside for the first year was fixed to COP surfaces and liable to modification by the States in the following years (Tab. 1).

Set aside was applied in different manner trough by the Italian farmers. More in details it is possible to observe the volatility of his applications between 1993 and 1999 (Tab. 2) due the variation of Set aside rate fixed by the Commission. Also, North and Centre Regions has applied Set aside much more than South Italy. This situation was exactly the opposite of the initial Set aside scheme, before Mc Sharry reform, where set aside (in voluntary form) was mostly in South Italy.

Table 1. Compulsory Set Aside: Payments and Percentage of retire between 1993 and 1999 years

Years	1993	1994	1995	1996	1997	1998	1999
Crops Campaign	92-93	93-94	94-95	95-96	96-97	97-98	98-99
Percentage of retire	15.00%	15.00%	12.00%	10.00%	5.00%	5.00%	10.00%
Base payment(Ecu/t)	45.00	45.00	68.83	68.83	68.83	68.83	68.83

Source: Elaboration from EU data

Table 2. Reform Mac Sharry and Set Aside. Analysis for areas (.000 ha)

	1993	1994	1995	1996	1997	1998	1999
			North				
Arable Crops	1.570	1.808	1.794	1.975	2.010	1.958	1.980
Set Aside Mac Sharry	98	125	118	116	78	78	135
Of which no-food	16	40	41	24	8	7	16
			Centre				
Arable Crops	969	1.202	1.231	1.309	1.301	1.238	1.241
Set Aside Mac Sharry	64	81	89	83	55	52	86
Of which no-food	16	20	21	16	5	5	10
			South and Isles				
Arable Crops	1.333	1.691	1.733	1.811	1.863	1.422	1.553
Set Aside Mac Sharry	32	41	39	38	28	26	37
Of which no-food	5	3	3	2	1	0,5	0,7
			Italy				
Arable Crops	3.872	4.701	4.758	5.095	5.174	4.618	4.774
Set Aside Mac Sharry	194	247	246	237	161	156	258
Of which no-food	37	63	65	42	14	13	27

Source: Elaboration from MIPA data

5.2 Results from the model application

The results obtained from the model application compare the observed situation in 1999, included set aside, with the scenario where Set aside is only "an option" for the farmers. It is clear that in case of no economic convenience of set aside "as a alternative crop" for the farmers, they can introduce other crops until to the availability of land in their farm.

In order to evaluate the effectiveness of Set Aside respect the two main objective persuaded by this policy (reduction of COP crop and reduction of subsidies paid to the farmers) are considered only three simple variables: a) if exist an economic convenience to set aside land even in the case of no-mandatory scheme, b) the variation of COP crop respect the actual situation, and c) if the total subsidies at farm level will change as a consequences of the variation of set aside presences. This analysis is carried out respect the situation of 1999, the year before the adoption of Agenda 2000.

Respect the economic convenience to adopt voluntary Set aside, at the level of subsidies given by the regionalisation plan, it is clear that was absolutely no convenient at all to adopt this policy. Only in Sicily and in Emila-Romagna Set aside still will continue to be present but with a strong reduction. On others Italian region Set aside disappears (Tab. 3) .

If we consider the effectiveness of Set aside respect the objective of reducing the surplus of some crops that exceed the market demand, it is clear how Set aside has strongly contribute to reduce the surplus of some COP crops. In fact, in absence of Set aside, the COP crops will increase by 9,4 % (in average), meanwhile cereal of 8% and oilseed of 22,6 %. It is interesting to note as the bigger increase of presence of COP crops should be in the Italian Regions where is higher the presence of this crops: Emilia-Romagna, Lombardia, Piemonte and Puglia (Tab. 4). In this sense, Set aside can be considered a very good policies able to reduce the supply of cereals and oil seeds.

The last point related to evaluation of the efficiency of Set aside as a tools able to help the farmers to sustain their activity even under the economic point of view, between the 1992 and the 1999, is represented by the variation of the subsidies perceived at farm level due Set aside effect (Tab. 5). Related to this aspect, the consequences of the increasing surface of COP crops, is also the cost rise related to the CMO scheme for arable crops. The system of payment based on partial decoupled system, in fact, allow the farmers to increase in meaningful manner the total subsidies related to the first pillar, pushing, at the same time, the EU spend more funds to retire from the market the surplus of products.

Table 3. Presence of Set aside in case of volountary scheme – Italy (value in Ha)

Region	Observed Set aside surface (mandatory)	Estimated Set aside surface (voluontary)
Abruzzo	3,353	
Basilicata	4,804	5
Calabria	1,375	
Campania	2,354	2

Emilia-Romagna	22,546	420
Friuli	11,582	
Lazio	11,761	
Lombardia	43,549	
Marche	14,991	
Molise	4,125	
Piemonte	26,900	
Puglia	15,846	
Sardegna	5,250	
Sicilia	4,772	567
Toscana	25,940	
Umbria	11,834	
Veneto	24,109	
Italy	329,996	994

Table 4. Land use variation respect the baseline for region (in Ha and in %)

Regions		COP Crops	Cereals	Oilseeds
Policy scenario	(Baseline - Ha)	Voluntary Set aside (Var. %)		
Abruzzo	36.280	9,5	3,7	67,4
Basilicata	52.197	5,1	7,2	-100,0
Calabria	49.928	6,1	6,6	-20,8
Campania	18.966	3,3	2,4	11,0
Emilia-Romagna	199.432	14,8	11,4	34,0
Friuli V-G	8.665	9,0	2,5	25,9
Lazio	47.587	11,6	11,7	22,0
Lombardia	168.017	13,3	12,3	20,8
Marche	92.174	14,4	21,0	-17,6
Molise	14.747	9,0	3,7	48,1
Piemonte	163.217	15,3	17,8	-4,9
Puglia	108.175	10,5	11,9	-13,6
Sardegna	17.097	4,1	9,6	-41,1
Sicilia	99.373	8,7	4,8	247,8
Toscana	31.638	12,6	-3,6	82,7
Umbria	17.472	9,9	12,7	7,1
Veneto	55.728	2,3	-2,0	14,7
Italy	1.180.692	9,4	7,9	22,6

Table 5. Variation of direct payment due liberalization of Set aside (value in .000 of Euro and in %)

Regione	Baseline Mandatory Set aside	Policy scenario Voluntary Set aside	Variation in %
Abruzzo	25.822	29.912	15,8
Basilicata	30.041	30.791	2,5
Calabria	12.337	12.624	2,3
Campania	30.432	30.810	1,2
Emilia-Romagna	174.751	194.072	11,1
Friuli	80.966	84.984	5,0
Lazio	76.852	84.579	10,1
Lombardia	263.612	275.853	4,6
Marche	105.632	113.931	7,9
Molise	30.206	33.812	11,9
Piemonte	143.568	150.973	5,2
Puglia	112.095	119.711	6,8
Sardegna	32.576	28.606	-12,2
Sicilia	42.022	49.343	17,4
Toscana	140.262	167.768	19,6
Umbria	58.621	61.179	4,4
Veneto	254.455	264.320	3,9
Italy	1.614.250	1.733.268	7,4

6. Conclusion

In sum, the exposed model allowed to produce an ex-post evaluation on the Italian Set aside rule application. And, thanks to the harmonization of information taken from two data-warehouses this model has kept in account the features of each region composing the Italian agricultural production structure.

In particular, the paper demonstrates how starting from a micro information, it is possible building a regional supply model able to simulate CAP measures effects both in ex-ante and in ex-post framework for an entire region. From a methodological point of view, the evolution of PMP approach, presented in this paper, has allowed to overcome some PMP limits, leaving more flexibility and, hence, more analysis capability to the model.

For what concerns the Italian Set aside application and the objectives pursued by the EU regulation, it can be enhanced the efficiency and effectiveness of this agricultural policy. Model results let see how the set aside payment absence would have pushed farmer on COP crops. The effects of this behaviour would be negative: prompt on already exceeding plantings, with the following market price reduction and, hence, increasing cost affecting the policy of agricultural income support. On the other hand, Set aside endorsed to limit the agricultural budget, through just not increase the exceeding growing's production.

Finally, using SPEP methodology could endorse a deeper evaluation of the policy maker instruments, by assessing their decisions' efficiency.

References

Agrawal R.C. and Heady E.O. (1972): *Operations Research Methods for Agricultural Decisions*, The Iowa State University Press, Ames.

Ahner D. (2001): "Experience and perspective of the EU Commission's DG Agri", in Heckelei T. (ed.), *op. cit.*: 310-3113.

Barkauoi A., Butault J.P. and Rousselle J.M. (1999): *Mathematical Programming and oilseeds supply within EU under Agenda 2000*, Proceedings of Eurotools Seminar.

Bascou P. (2000): Utilisation de la modélisation dans le cadre de la Politique Agricole Commune, Mimeo, 4, 6.

Burrel A. (1995): "Conception et performance des modèles du secteur agricole", in Burrel A., Henrichsmeyer W. and Garcia Alvarez-Coque J.M.., *Modélisation du secteur agricole*, Eurostat, Luxembourg.

Garvey E., Steele S. (1998): *Short term forecast of structural changes in Irish agriculture*, CAPRI Working Papers, University of Bonn.

Hazell P.B., Norton R.D. (1986:) *Mathematical Programming for Economic Analysis in Agriculture*, McMillan Publishing Company, New York.

Heady E.O., Egbert A.C. (1964): "Regional Programming of Efficient Agricultural Production Patterns", *Econometrica*, 32 (3): 374-386

Heady E., Meister A.D., Chen C.C. (1978): *Quadratic Programming Models Applied to Agricultural Policies*, Iowa State University Press, Ames.

Heckelei T., Britz W. (2001): *Concept and explorative application of an EU-wide , regional Agricultural Sector Model (CAPRI-Project)*, in Heckelei T., Witzke P. and Henrichsmeyer W., *Agricultural Sector Modelling and Policy Information System*, Wissenshaftsverlag Vauk Kiel KG, Kiel.

Howitt R.E. (1995): "Positive Mathematical Programming", *American Journal of Agriculture Economy*, 77: 329-342.

Jayet P.A. (1990): *Agricultural supply modelling for the Common Agriculture Policy: a modular approach base on Linear Programming*, Working paper, INRA-Grignon.

Jones P.J., Rehman T., Harvey D.R., Tranter R.B., Marsh J.S., Bunce, R.G.H. and Howard D.C. (1995): *Developing LUAM (Land Use Allocation Model) and modelling CAP reforms*, CAS Paper 32, The University of Reading, Centre for Agricultural Strategy.

Judez L., Gonzalez A., Ibanez M., De Andres R., Urzainqui E., Chaya C., Fuentes-Pila J. (2000): *Application of a model of PMP to analyse the effects of the measures of Agenda 2000 in*

Spain, in Heckelei T., Witzke P. and Henrichsmeyer W., *Agricultural Sector Modelling and Policy Information System*, Wissenshaftsverlag Vauk Kiel KG, Kiel

Kleinhanss W. (2002): *Phasing out Milk Quota – Possible Impact on German Agriculture*. Federal Agriculture Research Centre, FAL, Braunschweig.

Paris Q. and Arfini F. (1995): "A positive mathematical programming model for regional analysis of agricultural policies", in Sotte F., *The regional dimension in agricultural economics and policies*, Proceeding EAAE Seminar, Ancona.

Paris Q., Arfini F. (1999): *Assessment of Agenda 2000's impact on the Emilia Romagna Region agricultural system using aggregate FADN data*, Proceedings of Eurotools Seminar.

Paris. Q., Arfini F., Donati M. (2002): *CAPSET report: The CAP reform Set aside and the arable crops sector in Italy: an integrated evaluation approach*, Dipartimento di Studi Economici e Quantitativi, Parma.

Paris Q., Arfini F. (2000): "Funzioni di Costo di Frontiera, Auto selezione, Rischio di prezzo, PMP e Agenda 2000", *Rivista di Economia Agraria*, 2: 211-242.

Paris Q., Easter C.D. (1985): "A Programming Model with Stochastic Technology and Prices: The Case of Australian Agriculture", *American Journal of Agricultural Economics*, 52: 120-129.

Paris Q., Howitt R.E. (1998): An Analysis Of Ill Posed Production Problems Using Maximum Entropy, *American Journal of Agricultural Economics*, 80: 124-138.

Paris Q., Montresor E., Arfini F., Mazzocchi M. (2001): *An Integrated Multi-phase Model for Evaluating Agricultural policies Trough Positive Information*, in Heckleli T., Witzke P and Henrichsmeyer W. *Agricultural Sector Modelling and Policy Information System*. Wissenshaftsverlag Vauk Kiel KG, Kiel

Paris Q. and Howitt R. (2001): "The Multi-Output and Multi-Input Symmetric Positive Equlibrium Problem", in Heckelei T., Witzke H.P., Henrichsmeyer W. (eds.): *Agricultural Modelling and Policy Information System*, Wissenschaftsverlag Vauk Kiel KG, Boon.

Paris Q. (2001): "Simmetric Positive Equilibrium Problem: a framework for rationalizing economic behaviour with limited information", *American Journal of Agricultural economic*s, 83(4):. 1049-1061.